DESIGN FOR THE OUTER HARBOR OF CHICAGO, ILLINOIS

BY

T. J. FERRENZ

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1911

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The Proposed Outer Harbor
of
The City of Chicago

A Thesis
by
T. J. Ferrenz.

May 15 1911

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DESIGN FOR THE PROPOSED OUTER HARBOR
OF
THE CITY OF CHICAGO

A THESIS

PRESENTED BY
TIRRELL J FERRENZ

TO THE
PRESIDENT AND FACULTY
OF
ARMOUR INSTITUTE OF TECHNOLOGY
FOR THE DEGREE OF
BACHELOR OF SCIENCE IN CIVIL ENGINEERING
HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN
CIVIL ENGINEERING

1911

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PART I

DISCUSSION OF THE HARBOR PROBLEM

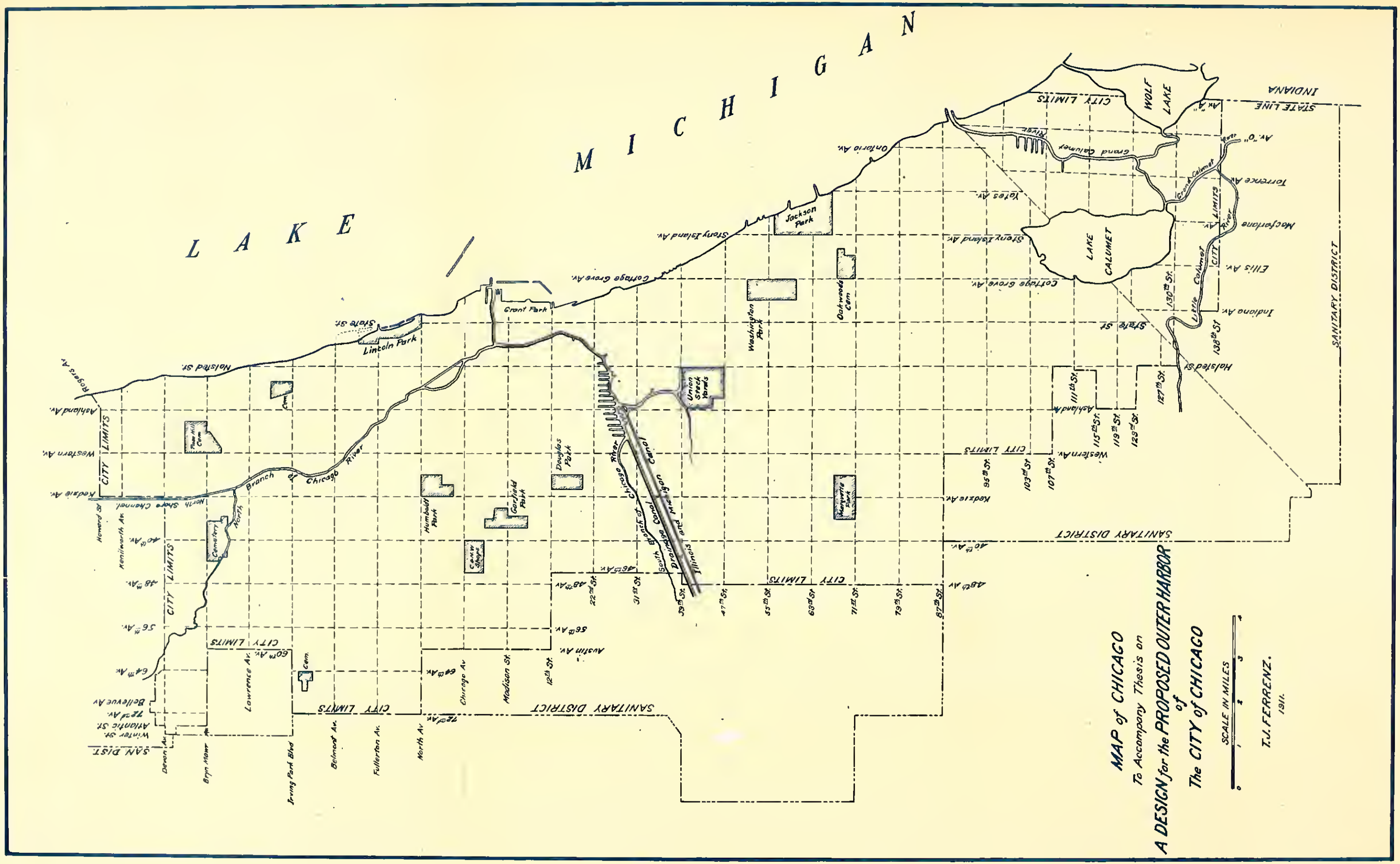
PART I

DISCUSSION OF THE HARBOR PROBLEM

INTRODUCTORY STATEMENT

At the present time the City of Chicago is confronted by three great economic and engineering problems involving the health, convenience, and prosperity of its inhabitants. These are:1, Electrification of Railways; 2, Subway Construction; and 3, Expansion of Harbor Facilities. The first has been postponed repeatedly through the powerful opposition of the railroads who have advanced various arguments of financial disability and insufficiency of working data, but the impetus derived from New York's successful experiment and the voluntary action of the London and South Western Railroad in deciding to electrify its entire system of 273 miles, makes it certain that this desirable improvement will be commenced in the near future.

Subway construction has received a large amount of attention of late and tentative plans have been prepared for the city. A glimpse of Chicago's "loop"



MAP of CHICAGO
To Accompany Thesis on
A DESIGN for the PROPOSED OUTER HARBOR
of
The CITY of CHICAGO

T. J. FERRENZ.
1911.

ments through the freight tunnel, and when we add the conflict with park development and the "City Plan", the whole aggregation becomes a problem of the greatest magnitude.

DECLINE OF COMMERCE

Another and a serious phase of Harbor problem is presented by the decline of commerce. Chicago has developed its wonderful prosperity from its commerce and manufactures, and anything which tends to retard either of these strikes directly at its future growth. It is a well known fact borne out by statistics* that Chicago's lake trade has been steadily declining for a number of years while that of other and less favorably situated ports has increased. Milwaukee, Duluth, Cleveland and Buffalo all show great expansion. Since 1900 the total freight tonnage on the Great Lakes has more than doubled, but in spite of this fact the Port of Chicago as a whole to-day occupies the same position it did twenty years ago. This stationary condition

*See Tables 1 – 5, inc.

is due to the fact that although Chicago proper has suffered a large decline, the commerce of South Chicago has grown proportionately. However, the increase at the Calumet River is made up entirely of receipts of ore so that it has not gained the traffic which the Chicago River has lost.

There are two reasons why Chicago shipping has declined. One of these is natural shifting and change of business, the natural falling off of some of the commodities of lake commerce — notably lumber and, to a less degree, coal. The other reason is the artificial obstructions to navigation which has made it both impossible and uneconomical for shipping to do business in the river. The advent of larger ships and the disappearance of smaller ones, narrow and crooked channels, numerous bridges, the nuisance of bridge hours, shallow water over the old tunnels, and narrow openings at the center pier bridges, have all combined to produce the conditions.

The accompanying diagrams* which are based on statistics taken from the Report of the Harbor

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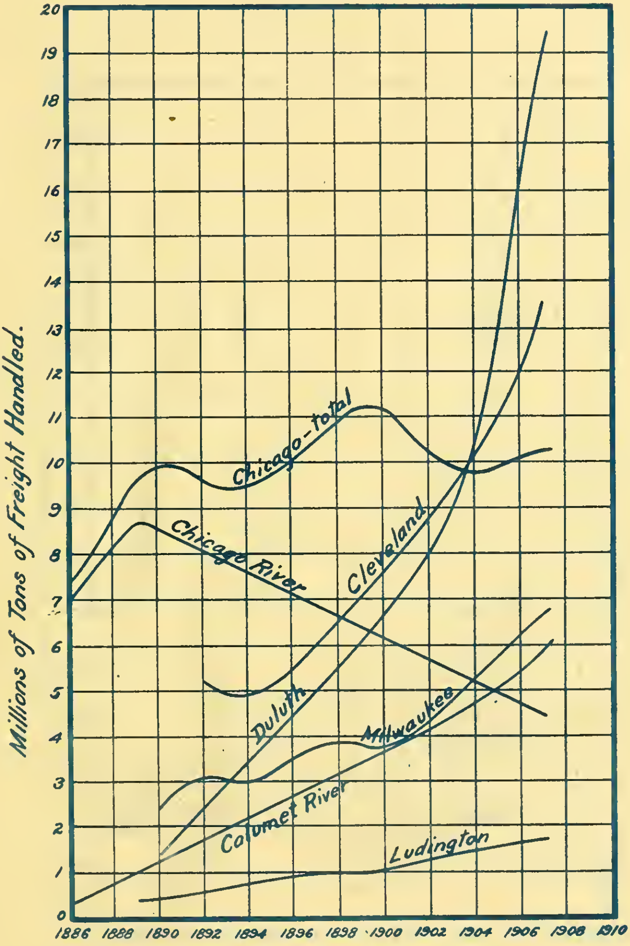
*See Jour. W.S.E.Vol.15,Report on Chicago Harbor Problem.

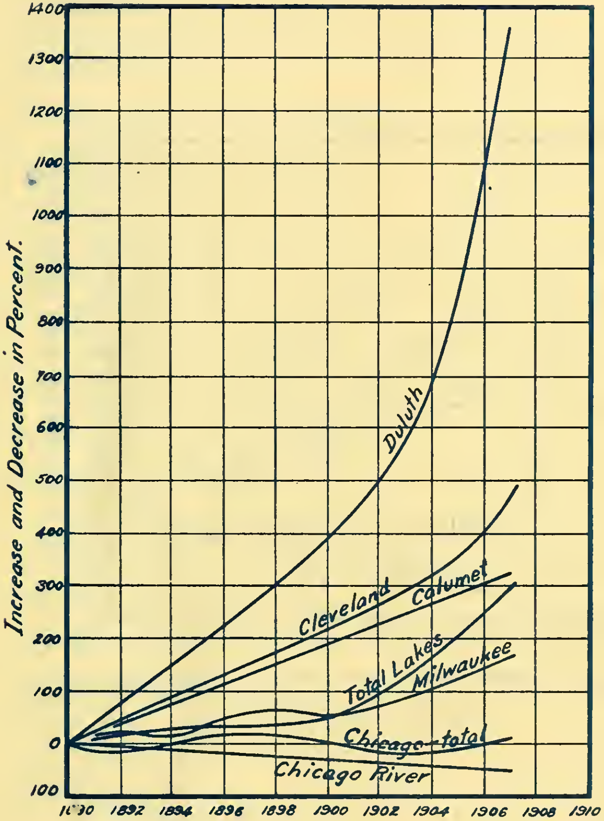
Commission and data furnished by the Board of Trade, will illustrate the general state of affairs. Chicago's actual condition is indicated in a marked degree by Fig. 3, which shows for the ten years from 1900 to 1910 that while Chicago's population has increased 42 %, freight business for the Port has declined 8.5 % and at the Chicago River 28 %, while during this period Milwaukee has made a gain of 77 % and the total lake commerce has increased 11 %.

Fig. 1.



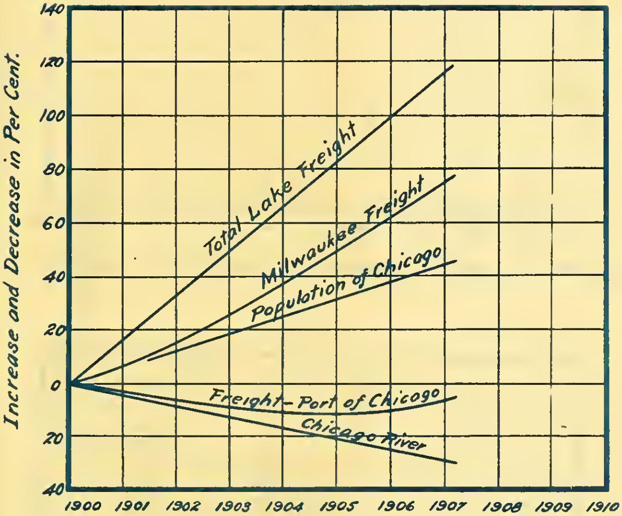
Volume of Commerce at Various Lake Ports.

Fig. 2.



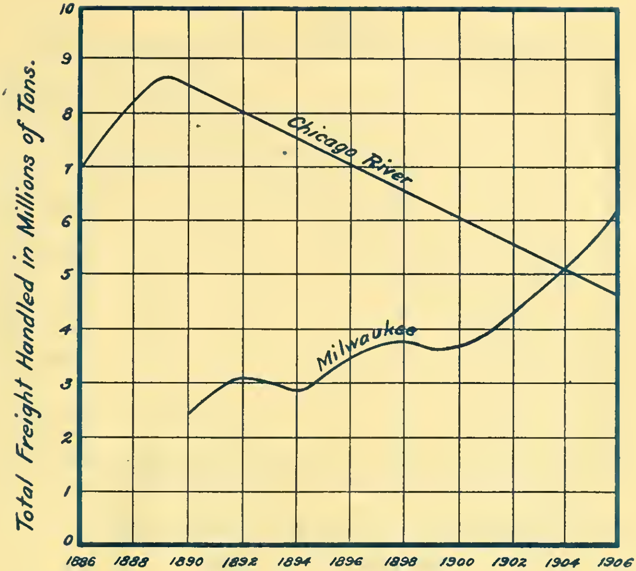
Comparative Increase and Decrease of Commerce at Various Lake Ports.

Fig. 3.



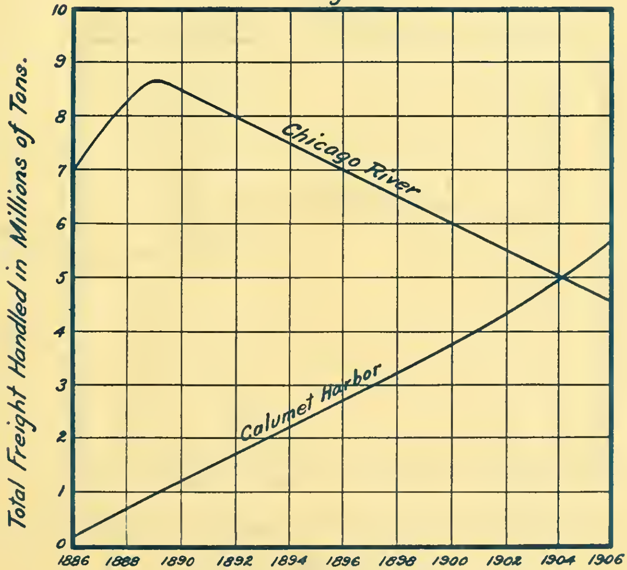
Decrease of Lake Commerce at Chicago Compared with General Development.

Fig. 4.



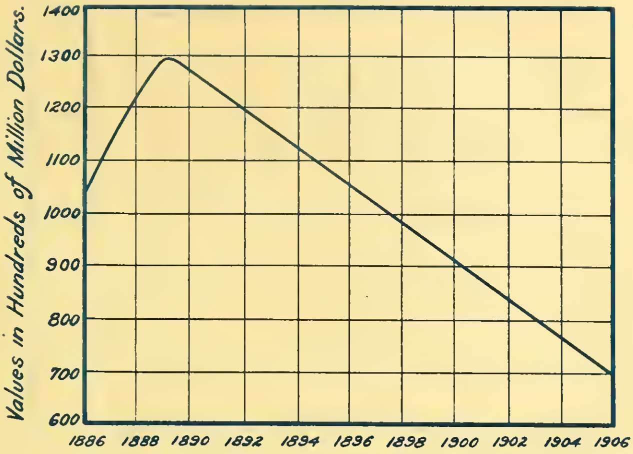
Comparison of Freight Tonnage of Chicago and Milwaukee.

Fig. 5.



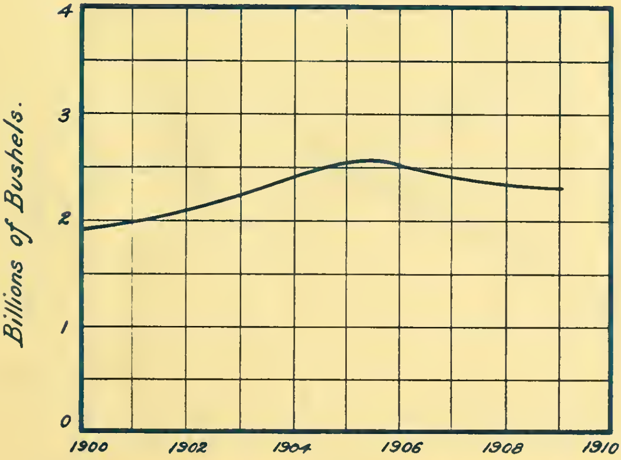
Comparison of the Growth at the Calumet and
the Decline at Chicago River.

Fig. 6.



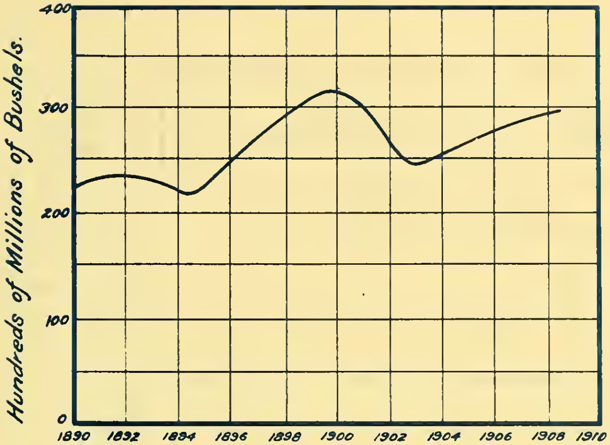
Value of Freight Handled at the Chicago River.
Basis of $150 per ton.

Fig. 7.



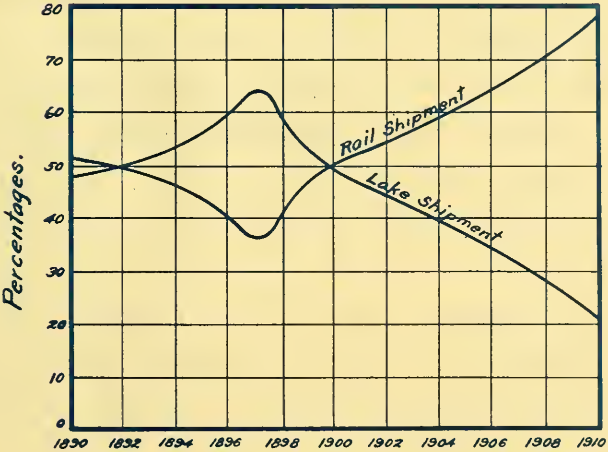
Production of Grain in Territory Contributory to
the Chicago Market.

Fig. 8.



Grain Receipts at Chicago and South Chicago.

Fig. 9.



Shipments of Grain from Port of Chicago by Lake and Rail.

REVIEW OF LOCAL IMPROVEMENTS AND EXPENDITURES

It is interesting to note that more than forty years ago the authorities were planning elaborate harbor developments, although extensive improvements had been undertaken previous to that time. In fact harbor developments began as far back as 1833 with an appropriation of $25,000 by Federal government. The project involved consisted in the formation of a channel of entrance through the river mouth between two piers extending into the lake. Before the work was completed, it became evident that the plan of the improvement was wrong,for,the winds and currents had formed a sand bar across the end of the North pier. This process of deposition continued so swiftly that by 1838 the shore line had extended into the lake seven hundred feet along the north pier. The direction of the pier was then changed 25 $\frac{1}{2}$ degrees to the north, but without any better results.

Up to and including 1869, the government had expended $41,600 and the City $14,700 in attempting to improve the harbor. In 1867 government engineers

advised the construction of an outer harbor and in futherance of that recommendation protecting breakwaters were built, but in the controversy and litigation between the public and the Illinois Central Railroad over the question as to who should control the proposed harbor, the improvement was blocked. Since then both City and Federal government have expended large sums on harbor improvements. According to Mr.A.M. Liljencrantz,M.W.S.E., the expenditures have totalled as follows:–

CHICAGO RIVER,

Dredging River and branches to 17 ft. depth, 1896 - 98. – – – – – –	$189,351.75
Widening at narrowest bends and dock corners 1899–1901(including cost of removed land and building new docks) – – – – – – – – – – – –	$203,788.68
Constructing two turning basins – – –	$464,900.22
Dredging and rock excavation to 21 ft. depth,1908 - 9 – – – – – – – – – –	$458,469.05
Salaries and other contingencies – –	$ 24,276.95
Total – – –	$1,340,786.65

CHICAGO HARBOR - - - - - - - - - - - - - -	$2,552,039.85
CHICAGO RIVER - - - - - - - - - - - - - - -	$1,340,786.65
CALUMET HARBOR, Dredging, Piers, and Breakwaters -	$1,479,788.48
CALUMET RIVER, Dredging and Rock Excavations- - -	$ 860,503.79
GRAND TOTAL, Dec. 1909, -	$6,233,118.77

ACTIVITIES OF OTHER CITIES

In spite of these large outlays, harbor development has failed to keep pace with the requirements of commerce. If Chicago is to maintain her commanding position and become the greatest city of America, as Baron Rothschild once predicted, she must be alive to existing conditions. Other cities are improving their harbor facilities and are making great efforts to increase their commerce. Cleveland and Buffalo both have recently constructed new breakwaters. Philadelphia has organized a Harbor Commission, while New York, Boston, Baltimore and San Francisco are making improvements, which involve the expenditure of many millions. The Fed-

eral government, too, has done more for other harbors[*] Chicago ranks sixth in absolute amounts received, and last in proportion to population.

CHICAGO'S STRATEGIC POSITION

A port becomes a great commercial focus in proportion to the development of certain factors which determine the flow of commerce. —:— First: The production of goods in the interland, which may find, by way of the port, a market in the world outside. Second: The degree in which the interland becomes an active market for the importation of goods from other productive regions. Third: The development of facilities for the efficient handling and transportation of goods.

Chicago possesses an especially advantageous location as a commercial and industrial center. The richness of the surrounding agriculture and stock-raising area, the nearness of immense deposits of coal and ore, and the presence of large timber supplies adjacent to the Great Lakes are all important factors which have entered into the development of

[*] See Report Harbor Commission, pp. 263-6.

—:— Prof. J. Paul Goode.

this city into a metropolis. The attendant expansion of commerce and industry has made Chicago the greatest railroad center in the world, and has caused it to rise within the memory of living men to the position of fifth among the great cities of the earth.

The advantages of St. Louis with reference to the enormous central area of production just mentioned were equally as great, if not greater, than Chicago's, but she lacked a water route to the East. Chicago's location at the foot of Lake Michigan gave her a choice of transportation routes, while the potential competition of the water routes forced the rates by rail far below those granted to interior cities. This discrimination, which was of great benefit to merchants here, in turn diverted a large amount of East-West freight to the route along the Great Lakes.

LOCATION OF HARBOR

Consequently, since Chicago's supremacy and prosperity has been based largely on this water route, the conservation and progressive improvement of

water facilities is of vital importance. In considering the location of desired improvements, it is well to remember that harbors, as classified by Mr. John M. Ewen, are of two kinds, commercial and industrial. A "Commercial Harbor" is one which is located conveniently near the heart of the city and which makes provision for the delivery of passengers arriving by vessel, and for the freight that is used locally, including coal, fruit, vegetables and merchandise. Such a harbor must also provide for a certain amount of through business handled by steamers carrying local freight. An "Industrial" Harbor supplies facilities for handling commodities which are required for manufacturing, and also traffic which is in transit through the city. It should be located in a manufacturing neighborhood where land is cheap and where railroads with their freight yards, switch tracks, etc., are in close proximity.

In 1909 the Harbor Commission recommended that an industrial harbor be constructed at South Chicago by the transformation of Lake Calumet, and a bill providing for such an improvement is now pending before the State Ligislature. The proposed

project (see map) contemplates cutting a channel 300 feet wide from the Calumet River to the North end of Calumet Lake, then dredging a channel 1000 feet wide to the Southwest corner of the lake and filling in the remainder of the lake with the spoil from this excavation. The report of the Chiperfield Committee on submerged lands shows that there are 2715.03 acres included within the meander lines of Lake Calumet, 387.99 acres of which are land. Exclisive of the part used for the channel and adjacent slips, hundreds of acres of land can be created, the value of which would cover the cost of the undertaking.

The Calumet District offers an ideal situation for a great industrial harbor. Located away from the valuable residence districts, and in a manufacturing region where large tracts of cheap land are available for factory sites, and with the possibility of cheap power from the Sanitary District, such a harbor would afford advantageous connections with thirty-four railroads now entering Chicago and would provide for the handling of all traffic by direct communication between rail and water.

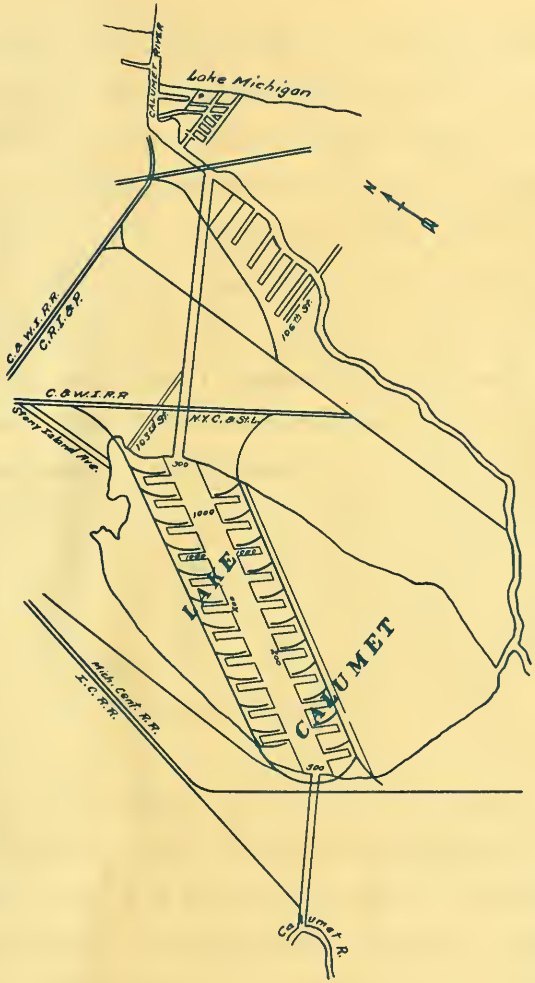


Fig. 10.

Diagram Showing Proposed Development of Lake Calumet for Harbor Purposes.

In regard to the location of the commercial harbor there are considerable variations in views. The officials of the steamship lines engaged in passenger, package, and fruit business are generally of the opinion that the best thing that could be done to satisfy their needs would be to construct three piers projecting into the lake, just north of the river mouth, as recommended by the Harbor Commission. This location is reached by only one freight railroad, the Northwestern, but as it is difficult and costly to build elaborate terminals and bring railway tracks to docks, the easiest and least expensive scheme would be to transport loose freight and loaded railway cars to and from the docks and rails by means of lighterage and car ferriage.

The port of Hamburg had to face a somewhat similar problem to that which confronts Chicago at the present day.* The enormous increase in draft in the Trans-Atlantic steamships had to be met, and that city's solution of the problem was an outer harbor and the lighter. The lighter is one of the great causes of New York's supremacy in the United States.

*See Report of Harbor Com.,"Development of Commercial Ports" by J. Paul Goode.

According to the census report of 1906, there was a traffic by water in New York harbor of over 113,000,000 tons, of which about 33,000,000 tons was in the coast trade, 25,000,000 tons in foreign trade, and 55,000,000 in harbor traffic — that is, there was a barge and lighter traffic far in excess of the combined rail and water commerce of Chicago.

One fact is certain, the Chicago River has not taken care of the City's commerce for the past ten years and is not doing so now. As far back as 1867, Colonel Wheeler, then District Engineer, and also a special board of other Engineer officers, reported that the Chicago River was not then, and never could be, able to take care of its growing commerce, and that the occupation of the lake front by docks and piers was a public necessity. The current alone has destroyed the river for harbor purposes, and with bridges occurring every three or four hundred feet apart, it is impossible to bring in any of the large modern ships. If freight is to be carried cheaply, it must be carried in large quantities; this is borne out by the fact that nearly three-fourths of the commerce of the Great Lakes is handled by vessels four hundred feet or more in length.

As illustrating the unsatisfactory condition of terminal facilities at Chicago, it is reported that sugar is now received at Milwaukee by water and then brought to this city by rail, because facilities for disgharging cargo are so much more favorable at Milwaukee as to compensate for the additional rail charge from that port to this. According to Mr. William H. Johnson, General Western Agent of the Anchor Line, the disabilities of steamers doing business at Chicago as compared with other ports are as follows:– Loading and unloading freight, Chicago, thirty-nine cents a ton; Duluth and Milwaukee, twenty-three cents a ton. Towing bills, Chicago, 50 % greater than at any other port. Under the most favorable circumstances at Chicago, a steamer can handle 1200 tons a day; at Gladstone and Manitowoc, 3800 tons a day; at Duluth, 4000 tons per day. A 4000 ton steamer can take her load in one day at Duluth; it requires three days at Chicago.

Mr. Ford, another steamship agent, states; "The modern steamer costs from six to eight dollars an hour to operate after she is put in commission.

That makes nearly two hundred dollars a day for twenty-four hours, and the only way she can offset this cost is by running and earning it. Therefore, if a boat comes to Chicago, with a cargo and is twenty-four hours in getting rid of it, she is out two hundred dollars, not to include from two hundred to five hundred dollars for river towage. Naturally the owner will not send her here again, if he can possibly get a cargo elsewhere." This is true especially of steamers carrying miscellaneous freight for they must pick up and discharge their cargoes at various docks along the river, which results in delay, inconvenience, large cost for tug service, and frequent opening of bridges.

The Committee of the Western Society of Engineers on the Chicago Harbor Problem summarized the most important constructive features of the harbor problem in the following items;

(1) That the best location for the establishment of new docks is on the lake front at the mouth of the Chicago River.

(2) That the easiest, least expensive and, at the present time, most feasible connection be-

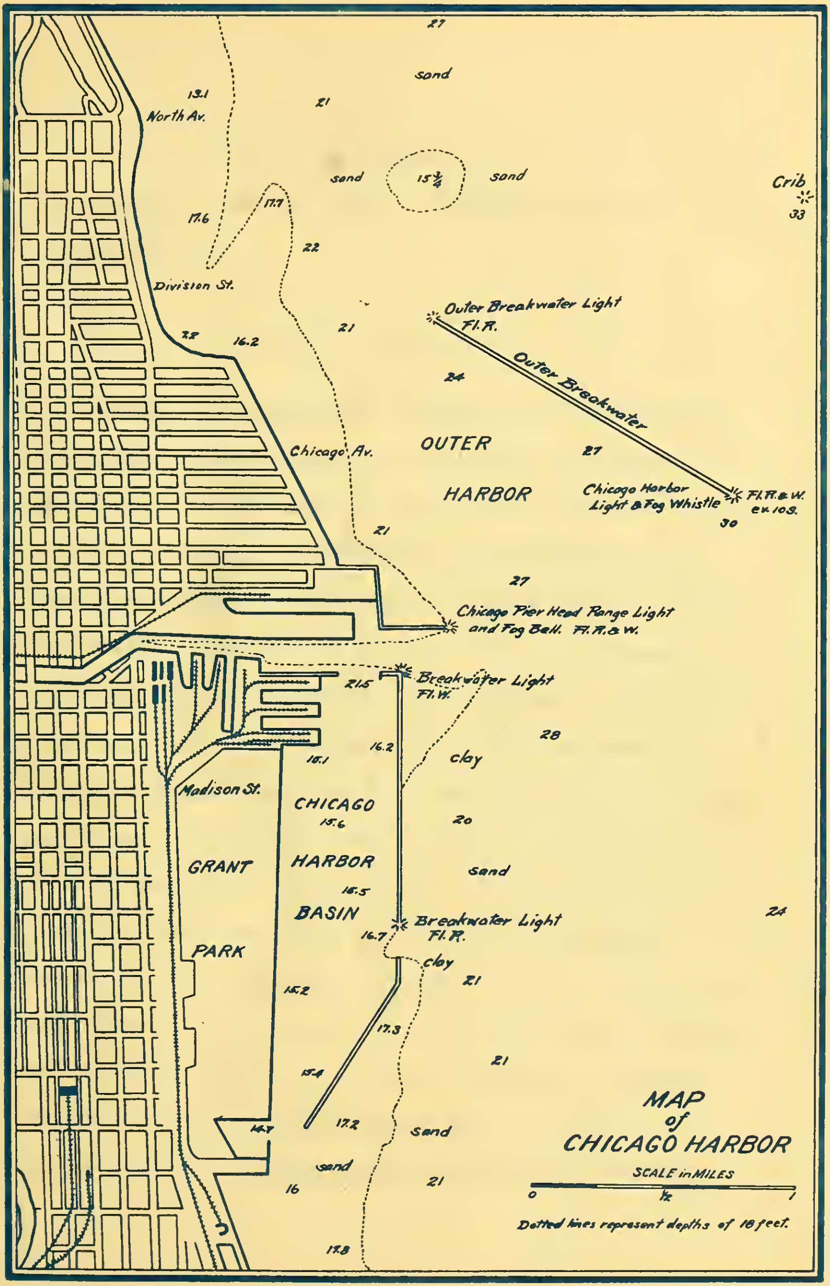
tween rails and docks in an outer harbor may be established by means of lighters transporting either railway cars or loose freight.

(3) That a lighterage service between different points on the river would afford a new and valuable system of transport for handling goods in competition with teams, which would result in economy as well as relief from congestion in the city streets.

(4) That while it is desirable to keep as much large shipping out of the Chicago River as possible, so that the interruption to traffic crossing bridges may be reduced to a minimum, hardships should not be imposed on shipping which finds it necessary to discharge and take cargo at docks located on the branches of the river.

(5) That if an entrance to a deep waterway through the Desplaines Valley to the Mississippi River becomes necessary, such entrance be in the Calumet district by way of the Sag Valley.

(6) That the development of the Calumet River be carried out, with a view to making it an inland harbor, rather than the Chicago River.


MAP
of
CHICAGO HARBOR
SCALE in MILES
0
½
1
Dotted lines represent depths of 18 feet.
North Av.
Division St.
Chicago Av.
Madison St.
OUTER
HARBOR
Outer Breakwater Light
Fl. R.
Outer Breakwater
Chicago Harbor
Light & Fog Whistle
Fl. R. & W.
ev. 10 S.
Crib
Chicago Pier Head Range Light
and Fog Bell. Fl. R. & W.
Breakwater Light
Fl. W.
Breakwater Light
Fl. R.
CHICAGO
HARBOR
BASIN
GRANT
PARK
sand
clay
27
13.1
21
15¾
33
17.6
17.7
22
7.8
16.2
24
27
30
21
27
21.5
28
16.2
15.1
15.6
20
15.5
16.7
24
15.2
17.3
21
15.4
14.7
17.2
16
21
17.8

(7) That any improvements be carried out in such a manner as to impose the least possible tax on shipping.

MUNICIPAL OPERATION

Municipal operation of public utilities has received a large amount of attention in recent years, but as yet has not acquired a very firm hold in this country. In Europe public ownership of docks and harbor facilities is the prevailing custom, but in the United States most of the docks and piers are provided by the railroads. This is true especially of Boston, Philadelphia, Newport News, Galveston and the Lake ports. Piers at Baltimore are municipally owned and are leased at a certain price per square foot, but the superstructures or sheds are built by the various lessees to suit their own requirements. The City of New York owns about twenty-five miles of the total Manhattan water front of forty miles. This is leased to shipping interests requiring wharfage, and is under the authority of the Department of Docks and Ferries,

which also has control over all work done on private water front property.

The committee of the Western Society on the Harbor Problem was of the opinion that public ownerships of harbor facilities was not in accordance with good policy; that it would not be necessary or desirable for the municipality to construct and own docks, to be leased to others, if private enterprise could be depended on to do so, but that it would be necessary for the city to exercise proper control over such facilities as would be developed by private interests.

In view of the fact that the City's financial situation is not such as to warrant it in undertaking the work of development on the basis of immediate municipal ownership, the practical thing to do seems to be to give the Sanitary Board the power to go ahead with this work. The Sanitary District is a creation of the State, is officered by citizens of Chicago, has a good business and engineering organization, and has at its disposal the funds necessary for undertaking and carrying on this work in a speedy and proper manner.

In conclusion it is only necessary to say that irrespective of whether the desired improvements are carried out by the City, the Sanitary District, or by private corporation, harbor developments should be along the line of a general plan which will give Chicago a harbor not only commensurate with present necessities, but one that will provide for future expansion.

TABLE I.

CHICAGO RIVER and HARBOR RECEIPTS.

	Unclassified Merchandise	Classified Merchandise	Ore and Ore Products	Coal	Grain	Building Material	Total	Grain
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Bushels
1886 -------	490 500	158 762	454 010	890 326	877	3 405 836	5 400 311	29 230
1887 ------	624 600	185 306	333 200	941 847	3 485	3 437 184	5 525 622	116 180
1888 ------	634 200	170 046	152 660	1 247 845	1 803	3 571 426	5 804 980	60 100
1889 ------	537 600	193 872	128 835	1 230 030	429	3 312 903	5 403 669	128 745
1890 ------	289 772	128 088	126 145	1 323 821	....	2 973 247	4 685 757	179 810
1891 ------	281 956	141 155	90 871	1 246 106	....	2 785 250	4 545 338	....
1892 ------	500 000	227 775	137 411	1 363 862	2 622	3 044 518	5 276 088	84 050
1893 ------	613 325	213 113	43 872	1 346 274	5 121	2 751 785	4 973 490	170 700
1894 ------	828 249	295 005	61 321	1 210 198	21 742	2 485 072	4 901 587	976 500
1895 ------	805 948	320 775	69 791	1 129 302	43 612	2 632 602	5 002 030	1 451 810
1896 ------	396 600	469 918	99 694	1 146 365	3 834	1 777 958	3 894 369	127 820
1897 ------	311 057	415 336	104 876	1 044 244	109 670	2 118 415	4 103 577	3 669 640
1898 ------	316 100	424 908	84 015	1 231 851	48 932	1 717 611	3 823 417	1 899 520
1899 ------	390 426	476 270	98 805	1 038 281	33 724	1 836 708	3 874 250	1 146 740
1900 ------	259 372	466 725	61 274	856 599	10 599	1 515 532	3 170 101	359 300
1901 ------	616 535	937 135	101 355	877 240	15 453	1 691 206	4 238 924	515 100
1902 ------	618 995	1 003 340	89 689	262 843	54 647	1 583 924	3 613 438	1 821 555
1903 ------	630 553	738 347	144 938	985 133	112 822	1 216 413	3 828 206	3 265 300
1904 ------	461 729	717 165	43 912	762 671	29 358	966 589	2 981 424	978 600
1905 ------	753 289	731 329	113 721	777 892	50 094	1 017 824	3 444 147	1 761 696
1906 ------	696 995	537 822	203 254	627 175	21 152	1 024 406	3 110 804	731 415
1907 ------	694 070	347 265	142 076	866 151	9 826	947 785	3 007 074	350 928

Statistics taken from Report Chicago Harbor Commission 1909.

TABLE II.

CHICAGO RIVER and HARBOR SHIPMENTS.

	Unclassified Merchandise	Classified Merchandise	Ore and Ore Products	Coal	Grain	Total	Grain Shipped Abroad	Grain
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Bushels
1886	123 000	198 214	12 107	....	1 559 068	1 892 389	269 417	56 299 333
1887	136 000	198 241	23 275	....	1 299 924	1 656 440	254 664	66 812 037
1888	151 000	226 143	13 952	....	1 724 274	2 115 369	238 042	68 070 160
1889	202 000	286 815	33 586	....	5 560 635	5 900 891	346 815	95 212 108
1890	102 000	269 952	36 145	....	2 115 660	2 523 757	298 547	83 260 510
1891	136 566	232 662	74 105	....	2 226 094	2 669 427	199 789	96 983 084
1892	170 707	339 275	80 239	4 467	2 542 216	3 136 904	224 409	96 802 958
1893	258 265	216 353	106 422	4 749	2 400 684	2 985 473	346 729	92 703 766
1894	145 308	332 896	103 788	4 621	1 720 736	2 307 649	117 031	59 440 840
1895	285 523	144 479	34 336	6 176	1 783 398	2 203 912	113 712	66 266 176
1896	178 000	470 930	115 973	....	2 039 756	2 804 659	249 092	76 966 667
1897	225 058	258 304	132 054	631	2 430 135	3 046 182	343 490	109 658 909
1898	303 776	210 012	116 502	2 782	2 935 165	3 568 237	930 255	111 899 285
1899	231 002	226 031	76 787	853	1 680 441	2 215 114	491 093	66 478 155
1900	202 695	360 952	45 057	....	2 094 265	2 702 969	570 033	80 971 370
1901	310 133	329 169	43 400	....	1 262 616	1 945 318	433 339	47 807 542
1902	395 925	342 735	6 490	....	856 456	1 601 606	387 575	31 618 020
1903	369 814	422 269	2 914	....	1 482 351	2 277 348	608 396	57 561 433
1904	315 335	250 685	2 340	....	896 287	1 464 647	279 011	32 389 401
1905	359 146	424 131	....	....	1 160 762	1 944 839	412 272	45 104 634
1906	353 762	453 654	....	....	1 093 566	1 900 982	352 938	40 988 345
1907	389 394	442 129	....	....	1 141 523	1 973 049	376 992	40 978 375

Statistics taken from Report Chicago Harbor Commission 1909.

TABLE III.
CALUMET RIVER and HARBOR RECEIPTS.

	Unclassified Merchandise	Classified Merchandise	Ore and Ore Products	Coal	Grain	Building Material	Total	Grain
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Bushels
1886 -------	500	35 838	317 412	43 489	....	85 831	483 070	....
1887 -------	450	67 944	349 360	41 202	....	110 558	569 514	....
1888 -------	1 600	54 665	279 710	88 575	....	55 967	480 517	....
1889 -------	1 900	34 294	562 115	99 335	....	58 187	756 496	....
1890 -------	20 736	42 390	703 149	98 000	....	911 800	1 776 075	....
1891 -------	41 251	54 216	977 626	113 880	....	823 091	2 010 064	....
1892 -------	50 000	79 906	1 334 433	123 000	....	147 157	1 734 496	....
1893 -------	50 000	56 445	350 725	117 602	....	112 906	687 678	....
1894 -------	50 000	87 059	861 178	94 383	....	113 674	1 206 294	....
1895 -------	50 000	173 786	1 856 700	139 262	....	160 060	2 379 808	....
1896 -------	2 150	119 628	1 212 905	213 935	....	194 736	1 743 350	....
1897 -------	5 109	151 253	1 734 086	257 064	15 406	200 019	2 362 937	539 030
1898 -------	4 737	169 183	2 273 467	310 800	....	439 015	3 197 202	....
1899 -------	3 174	169 633	2 203 267	296 524	19 614	139 086	2 831 598	660 000
1900 -------	6 774	177 803	2 333 381	126 795	10 290	115 920	2 773 963	343 000
1901 -------	2 315	193 950	2 660 055	185 165	7 200	203 719	3 252 404	240 000
1902 -------	9 900	178 535	3 334 841	36 669	53 133	192 305	3 805 383	1 771 112
1903 -------	11 412	45 379	3 129 100	265 482	27 448	145 961	3 624 782	955 600
1904 -------	1 860	18 505	2 568 440	262 182	81 020	110 315	2 982 322	959 000
1905 -------	19 036	42 675	3 213 626	260 813	23 175	175 642	3 734 967	780 500
1906 -------	6 094	28 300	4 085 121	287 386	12 160	126 607	4 545 658	405 000
1907 -------	3 713	35 107	4 719 914	642 440	23 360	133 146	5 557 680	794 000

Statistics taken from Report Chicago Harbor Commission 1909.

TABLE IV.
CALUMET RIVER and HARBOR SHIPMENTS.

	Unclassified Merchandise	Classified Merchandise	Ore and Ore Products	Coal	Grain	Total	Grain
	Tons	Tons	Tons	Tons	Tons	Tons	Bushels
1886	21	.....	40	.....	17 604	17 665	705 391
1887	.....	.....	.....	.....	18 757	18 757	634 331
1888	300	.....	1 930	.....	9 075	11 305	302 600
1889	.....	.....	.....	.....	4 456	4 456	158 000
1890	.....	.....	.....	.....	20 326	20 326	733 458
1891	.....	.....	1 872	.....	54 815	56 687	2 252 465
1892	.....	.....	5 500	500	82 411	88 411	3 393 115
1893	.....	.....	2 237	100	213 382	215 719	9 116 439
1894	1 500	.....	25 390	.....	203 713	230 603	8 499 370
1895	5 226	25 749	64 128	6 575	376 264	477 942	15 881 585
1896	21 515	32 738	116 456	.....	904 485	1 075 194	38 139 287
1897	14 839	44 161	68 546	7 815	995 820	1 131 181	45 334 480
1898	10 826	10 991	191 888	23 250	683 369	920 324	27 780 515
1899	5 685	47 018	31 684	3 355	310 534	398 276	12 204 090
1900	3 295	35 016	1 555	1 850	970 995	1 012 711	36 823 180
1901	20 020	31 005	13 040	.....	678 808	742 873	25 527 960
1902	37 600	73 457	21 368	.....	516 620	649 045	19 448 625
1903	30 996	54 804	9 640	.....	1 022 003	1 117 443	39 209 555
1904	61 408	59 031	18 649	.....	606 850	745 939	20 910 536
1905	85 883	89 303	.....	.....	620 241	795 427	23 339 693
1906	63 217	143 591	.....	.....	537 860	744 668	19 584 161
1907	58 292	132 551	.....	.....	686 824	872 667	25 043 286

Statistics taken from Report Chicago Harbor Commission 1909.

TABLE V.

TOTAL RECEIPTS and SHIPMENTS for CHICAGO and CALUMET HARBORS.

	Chicago River and Harbor			Calumet River and Harbor			Total Port of Chicago
	Receipts	Shipments	Total	Receipts	Shipments	Total	
	Tons	Tons	Tons	Tons	Tons	Tons	Tons
1886	5 400 311	1 892 389	7 292 700	483 070	17 665	500 735	7 793 435
1887	5 526 622	1 656 440	7 182 062	569 514	18 757	588 271	7 770 333
1888	5 804 980	2 115 369	7 920 349	480 517	11 305	491 822	8 412 171
1889	5 093 145	5 900 891	10 994 036	756 496	4 456	560 952	11 754 988
1890	4 685 757	2 523 757	7 209 514	1 776 075	20 326	1 769 401	9 005 915
1891	4 545 338	2 669 427	7 214 765	2 010 064	56 687	2 066 751	9 281 516
1892	5 276 088	3 136 904	8 412 992	1 734 496	88 411	1 822 907	10 235 899
1893	4 973 490	2 985 473	7 958 963	687 678	215 719	903 397	8 862 360
1894	4 901 587	2 307 649	7 209 236	1 206 294	230 630	1 436 897	8 646 133
1895	5 002 030	2 203 912	7 205 942	2 378 808	477 942	2 857 750	10 063 692
1896	3 894 369	2 804 659	6 699 918	1 743 350	1 075 194	2 818 514	9 517 872
1897	4 103 577	3 046 182	7 149 759	2 362 937	1 181 181	3 494 118	10 643 877
1898	3 823 417	3 568 237	7 391 654	3 197 202	924 324	4 117 526	11 509 180
1899	3 874 250	2 215 114	6 089 364	2 881 968	398 276	3 229 874	12 319 238
1900	3 170 101	2 702 969	5 873 070	2 773 963	1 012 711	3 786 674	9 659 744
1901	4 238 924	1 945 318	6 184 242	3 252 404	742 873	3 995 277	10 179 519
1902	3 613 438	1 601 606	5 215 044	3 805 383	649 046	4 454 428	9 669 472
1903	3 828 206	2 277 348	6 105 554	2 624 782	1 117 443	4 742 225	10 847 779
1904	2 981 424	1 464 647	4 446 071	3 982 322	745 939	3 728 261	8 174 332
1905	3 444 147	1 944 839	5 388 986	3 734 967	795 427	4 530 394	9 919 380
1906	3 110 804	1 900 982	5 011 786	4 545 648	744 668	5 290 326	10 302 112
1907	3 007 074	1 973 049	4 980 123	5 557 680	872 667	6 430 347	11 410 470

TABLE VI.

Year	Chicago	Milwaukee	Duluth	Detroit	Toledo	Cleveland	Buffalo
1886	228 366	140 765	202 803	3 127 445	.....	317 621	338 808
1887	159 968	192 416	179 354	2 795 653	.....	588 949	318 137
1888	84 672	148 672	195 662	2 968 537	.....	538 517	373 721
1889	240 480	153 517	115 153	3 153 844	.....	631 272	408 891
1890	532 756	208 929	192 332	4 959 965	.....	667 091	465 296
1891	429 144	180 434	249 620	5 246 311	.....	504 983	622 267
1892	321 322	171 179	339 569	5 290 850	.....	755 177	994 137
1893	2 290 830	214 492	440 633	5 263 357	.....	720 918	816 479
1894	289 169	269 332	668 621	5 098 485	.....	788 869	937 982
1895	543 142	544 172	732 837	5 101 211	.....	1 026 011	1 081 789
1896	539 881	292 705	806 223	4 987 990	.....	725 978	681 925
1897	500 238	317 425	607 071	5 303 119	.....	690 539	495 168
1898	259 689	340 048	458 913	5 506 865	.....	896 933	515 302
1899	325 514	391 971	690 472	6 019 026	.....	1 088 859	826 431
1900	443 660	356 049	650 487	6 274 837	354 225	376 050	796 040
1901	487 442	400 438	1 179 549	6 179 893	530 074	298 750	1 390 945
1902	480 514	285 774	1 103 808	6 690 630	642 132	107 620	760 044
1903	592 659	275 705	983 888	7 219 886	695 772	105 159	561 063
1904	784 265	343 717	986 751	7 297 241	733 126	101 693	492 258
1905	1 210 837	451 010	655 677	6 795 439	1 288 520	955 770	887 983
1906	1 818 194	484 691	1 051 074	7 403 154	1 565 056	805 340	895 549

Number of Passengers carried out of Chicago by boat in 1907: 1967394

Number of Passengers Carried on the Great Lakes from the Most Important Ports.
Reports of Federal Vessel Inspector.

TABLE VII.

Year	Length of Keel in Feet						Nº of Vessels
	1-100	100-200	200-300	300-400	400-500	500-600	
1896	16	8	5	18	12	....	59
1897	24	6	7	8	4	....	49
1898	37	9	5	6	9	....	66
1899	27	5	5	3	11	....	51
1900	17	6	7	1	18	....	49
1901	37	13	4	20	10	....	84
1902	17	7	3	27	9	....	63
1903	21	5	14	18	19	....	77
1904	9	3	4	3	5	1	25
1905	16	8	3	5	8	17	57
1906	16	7	7	4	13	45	92
Total	237	77	64	113	118	63	672

Classification of Vessels
Constructed on the Great Lakes, 1896-1906.

TABLE VIII.

Year	Number of Vessels	Net Tons	Average Tonnage
1888	222	101 103	456
1889	225	107 080	476
1890	191	108 526	568
1891	204	111 856	548
1892	169	45 969	272
1893	175	99 271	567
1894	106	41 985	396
1895	93	36 353	391
1896	117	108 782	929
1897	120	116 937	974
1898	87	54 084	622
1899	122	80 366	658
1900	125	130 611	1045
1901	175	169 085	966
1902	133	168 873	1269
1903	123	136 844	1112
1904	119	159 433	1339
1905	101	93 123	922
1906	204	265 271	1300
1907	117	244 291	2088

Number and Net Tonnage of Vessels
Built each Year on the Great Lakes, 1888-1907.

TABLE IX.

LAKE COMMERCE OF CHICAGO 1909.

Shipments		Chicago River	Calumet River	Total.
Flour	Bbls.	2 584 175	481 494	3 065 669
Wheat	Bush.	4 305 539	4 941 978	9 247 517
Corn	"	12 435 875	14 298 901	26 734 776
Oats	"	3 226 000	1 515 000	4 741 000
Rye	"	10 000	35 000	45 000
Barley	"	66 000	150 000	216 000
Grass seeds	Ton	3 090	275	3 165
Mill stuff	"	182 482	21 590	204 072
Oil cake	"	2 810	120	2 930
Broom corn	Bales	5 247	.....	5 247
Lard	Tierces	3 828	.....	3 828
Tallow	"	1 996	75	2 071
Meats	Bbls.	3 991	.....	3 991
Wool and Hair	Sacks	42 371	8 996	51 367
Oil	Bbls.	22 925	127 358	150 283
Merchandise (unclass.)	Ton	370 919	28 731	409 784

TABLE X.

LAKE COMMERCE OF CHICAGO 1909.

Receipts		Chicago River	Calumet River	Total
Coal, hard	Ton	573 866	216 893	790 759
Coal, soft	"	88 565	360 962	449 527
Salt	"	242 634	....	242 634
Iron ore	"	35 828	4 652 057	4 687 885
Cement	"	16 430	60	16 490
Lumber	M	368 562	13 658	382 220
Shingles	"	16 143	....	16 143
Lath	"	5 363	....	5 363
Posts	Pieces	380 178	29 000	409 178
Railroad ties	"	859 585	61 150	920 735
Telegraph poles	"	26 141	28 370	54 511
Wood	Cord	2 667	1 548	4 215
Copper	Ton	4 304	147	4 451
Sugar	"	81 481	....	81 481
Green fruit	Pkgs.	4 748 040	2 500	4 750 540
Wheat	Bush.	1 995 420	3 560 126	5 555 546
Barley	"	41 000	....	41 000
Oats	"	....	6 000	6 000
Merchandise (unclass.)	Ton	706 899	3 052	709 951

Statistics taken from Report Dept. of Public Works 1909.

PART II

THE PROPOSED DESIGN

PART II

THE PROPOSED DESIGN

GENERAL PLAN

The general plan for the harbor improvement contemplates the construction of three large piers; 141 feet wide, each projecting straight into the lake 1200 feet at or near the foot of Indiana St. The slips between piers are two hundred feet wide. As the business of the harbor increases, these piers can be progressively developed futher into the lake or else additional piers can be built. Protection on the East is afforded by the outer breakwater, and on the South by an extension of the present North pier. In order to break the sea from the North, either the government break-water is to be extended west-ward or else an arm built from Lincoln Park.

Like the new piers at Boston and San Francisco, these piers are covered completely by a structural steel roof system. Thirty–four feet on each side is utilized for ware-rooms, offices, waiting rooms, etc.

A roadway thirty-six feet in width, flanked on both sides by walks nine feet wide, extends the entire length with the exception of the outer twenty feet, which is open.

Seven steamship lines doing passenger, package and fruit business will use these piers. They are:

Graham & Morton Transportation Company, five steamers, Chicago to Holland and St. Joseph.

Goodrich Transportation Company, nine steamers, Chicago to ports in Wisconsin & Michigan.

Northern Michigan Transportation Company, four steamers, Chicago to Mackinac Island and intermediate points in Michigan.

Dunkley-Williams Line, five steamers, Chicago to South Haven.

Barry Transportation Company, two steamers, Chicago to Milwaukee.

Indiana Transportation Company, two steamers, Chicago and Michigan City.

Hill Transportation Company, two steamers, between Chicago, Waukegan and Kenosha.

Several of these steamers are used by a large number of passengers, at times amounting to 15,000 a day, who make excursions to nearby lake ports. For the accommodation of these passengers, the car line on Indiana St. is extended to the lake front, thus intercepting the Wells, Clark & State St. lines. The City Council has already granted the Chicago Railways Company a franchise for this extension.

Rail connections are supplied with the Northwestern Railroad so that freight may be transported directly to and from the docks. In case it should be desired to use any pier exclusively for bulk freight, railroad tracks could be run directly onto the pier with only a slight alteration of the original design. This could be accomplished by omitting the sidewalks and by building a track upon a system of trestle bents constructed independently of the substructure of the pier. A similar method was adopted at the Boston terminal of the Boston and Albany Railroad, in which case the tracks were depressed so that cars might be loaded and unloaded directly upon a level with the

floor of the pier.

The design of suitable wharfage structures for the harbor may be divided into three parts:(1) Piers: (2) Bulk-heads or sea-walls to retain the solid fill of the shore: (3) Pier-sheds or steel superstructure for the temporary storage of freight.

PIERS

The predominating motive in designing a pier should be the preparation of a suitable structure to serve as an intermediary in the reception and transmission of freight. It is in no sense a warehouse or a storage plant. In construction it should be light and elastic, rather than rigid. For this reason and also because of economy, most piers have been built of timber. If it were not for their perishability, wooden piers as now constructed, would be almost ideal, but even this is not a great drawback. The average life of a timber pier on the North and East Rivers, New York City, is about forty years, and it appears there that before a pier reaches its limits of durability it will more than likely have outgrown its usefulness and

will have to be replaced by a more modern structure. Furthermore, all timber structures in the New York Harbor are subject to the ravages of the teredo and limnoria, although it is interesting to note that sewage pollution has driven away this destructive form of animal life from several localities. Chicago docks have never been troubled in this way, as the waters of Lake Michigan are free from these animals.

In regard to costs, the New York Docks Department states that an eighty foot pile driven and cut off in the work costs from $18.00 to $20.00, and in case such a pile could not furnish the frictional resistance required, it can be logged so that it will drive to refusal, and would then cost about $28.00.

A concrete-steel pile, supported by surface friction would have but little more efficiency than a logged pile and would cost in the vicinity of $120.00, – from four to six times the cost of a wooden pile. Costs in Chicago for wooden piles are approximately the same, being 25c per linear foot.

While the number of reinforced concrete piers has been increasing lately, especially along the Pacific coast, yet it is a significant fact that the largest piers of recent construction have been of timber. This is true of the piers of the immense Chelsea Improvement Project, in the New York Harbor, of the Holland American Line pier at Hoboken, New Jersey, and of the ocean piers at the Boston terminal of the Boston and Albany Railroad.

From the above considerations of cost, utility, and general practice, it, therefore, seems that a timber pier best fulfills all the requirements. The construction of such a pier is very simple since the waters of Lake Michigan are shallow for a long distance from the present shore line, and would not be of greater depth than twenty-two feet at the end of the projected piers. In fact, at a distance of one mile from shore the water is only twenty-six feet deep.

The piers, as planned are of solid construction similar to those in the Baltimore Harbor, — that is, they are filled in with sand and clay ob-

tained by dredging the slips to a depth of twenty-three feet. Since the area of the slips is greater than that of the piers, it is estimated that the soil dredged from the slips will just balance the amount of fill required. Thus the whole project could be completed in a short time with very small expense.

The details of construction are as follows:– The piles are driven in transverse rows which are spaced ten feet apart. Extra transverse rows are inserted under the roadway making the spacing there five feet. In each transverse row the piles are spaced six feet on centers, except the three outer piles which are three feet on centers. The transverse rows are clamped together by means of two 6" X 12" sticks at the tops of the piles and are braced horizontally at 1.5 feet below city datum with 5" X 10" sticks. Both transverse and longitudinal rows are diagonally braced with 5" X 10" pieces, which extend from the horizontal bracing to the clamping.

Under the two outer corners of each pier there is placed a cluster of seven piles securely

chained together; this gives added stability and also forms a fulcrum for warping vessels into the slips. A cluster of four piles is placed under each column of the pier sheds.

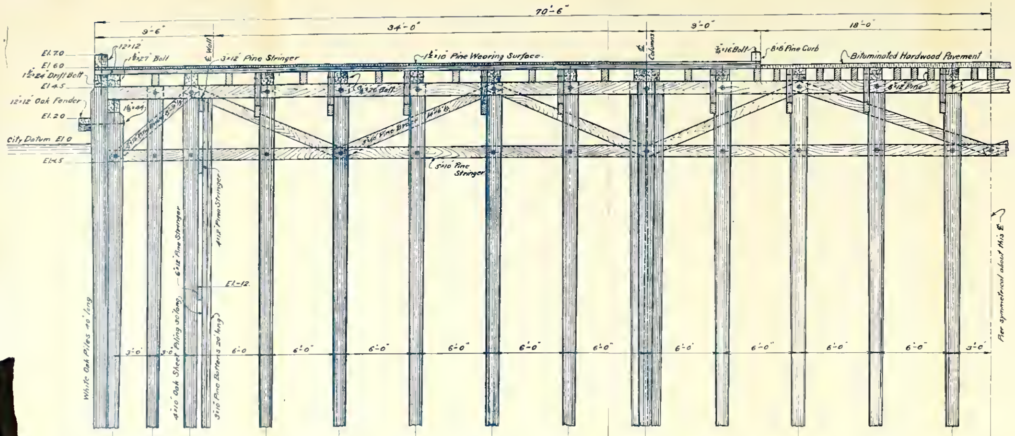
The floor system of the piers consists of 4" X 10" planking laid transversely across the ranger system which consists principally of 12" X 12" timbers capping the longitudinal rows of piles and extending the entire length of the piers. Midway between any two adjacent 12" X" 12" pieces are placed 6" X 12" pieces. Under the roadway an extra 6" X 12" is added and the two are then spaced 18" apart.

The wearing surface of the floor is composed of 1 $\frac{1}{2}$ " X 10" sheathing laid longitudinally. The sidewalks are composed of the same material laid transversely with $\frac{1}{2}$ " spaces. The roadway is paved with Shuman sectional bituminated hardwood paving, 3 $\frac{3}{4}$" thick. It is crowned 4" at the center. Curbing is formed by 8" X 8" sticks.

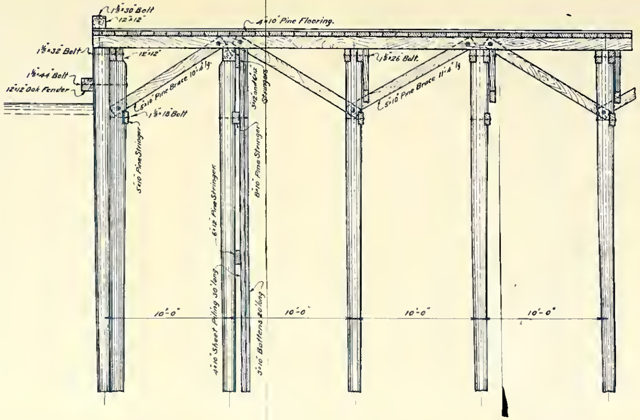
About ten feet from the outer end of every pier and six feet from each side, is placed a line

of sheet piling fastened to the adjacent pile rows. This piling consists of 4" X 12" planks, 30 feet long, battened with 3" X 12" stuff. Its purpose is to retain the solid fill of the piers.

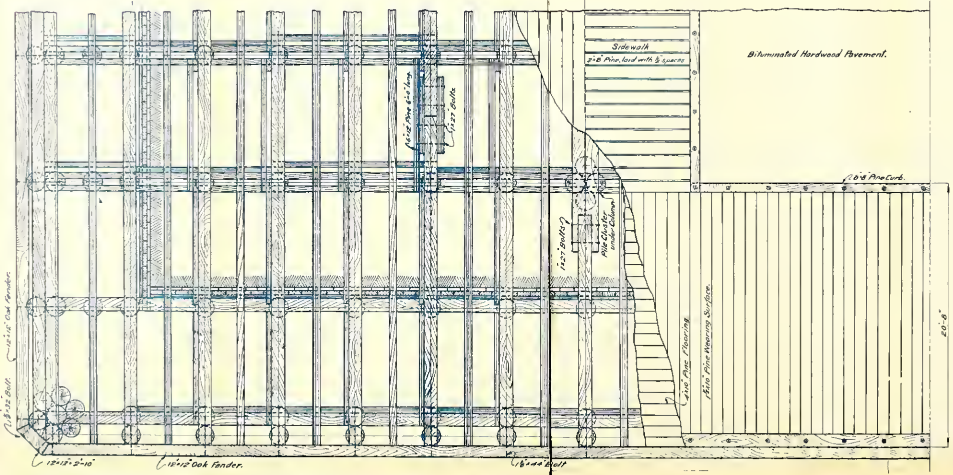
The entire pier, in each case, is surrounded by a fender system composed of 12" X 12" oak timbers which are placed at an elevation of two feet above city datum. Mooring posts, spaced forty feet apart, are placed along each side and the end of each pier and are securely braced and tied to inner piles. All the other parts of the piers are securely fastened with chains, dock spikes, drift bolts $1\frac{1}{2}$" X 24" and screw bolts which vary from 1" to $1\frac{1}{4}$" in diameter and from 12 inches to 12 feet in length. All joints in timber and all bearings where one timber crosses another are liberally treated with tar or dead oil, while the heads of piles are treated with asphaltic cement.



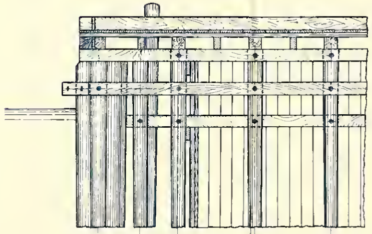
TRANSVERSE SECTION of PIER showing SIDEWALK and ROADWAY.



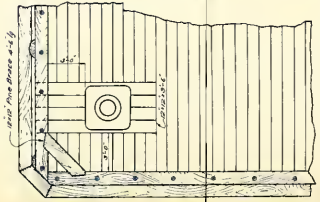
PART LONGITUDINAL SECTION
Piles spaced 5' c. to c. under roadway.



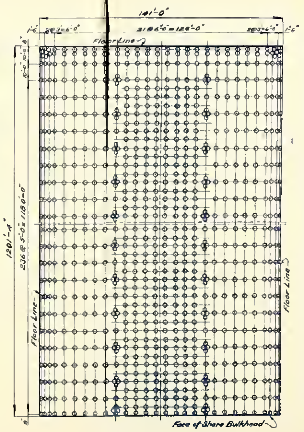
PART PLAN of PIER showing OUTER END.



END VIEW.



CORNER PLAN
Showing Snubbing Post.



PILE PLAN.
Scale: 1"=30'.

ARMOUR INSTITUTE OF TECHNOLOGY
CIVIL ENGINEERING DEPARTMENT

1200 Ft. PIER
For The Proposed
CHICAGO OUTER HARBOR

SCALE: ¼"=1'.
MAY, 1911.

Thesis of
T. J. Ferrenz.

BULKHEADS

The bulkheads are constructed, in the main, according to dock specifications of the City of Chicago, an extract of which is appended. They consist of oak piles, capped, sheathed with sheet piling and battens, and anchored back by wrought iron rods to anchor piles and back logs. Fender wales are attached to the bulkhead. The bulkheads are constructed in conformity with the piers, which are built into them at the shore inter-sections.

In general all timber for piers and bulkheads is of long leaf, southern, yellow pine. Piles are required to be of sound and straight white oak, white pine, yellow pine, Norway pine, or cypress with eight inch points and usually not less than 16" butts. They are forty and fifty feet in length and are driven until they refuse to penetrate further than one—third of an inch under the blow of a half—ton ram or hammer falling twenty feet, or a result of the same mechanical action from a dif) ferent weight and drop.

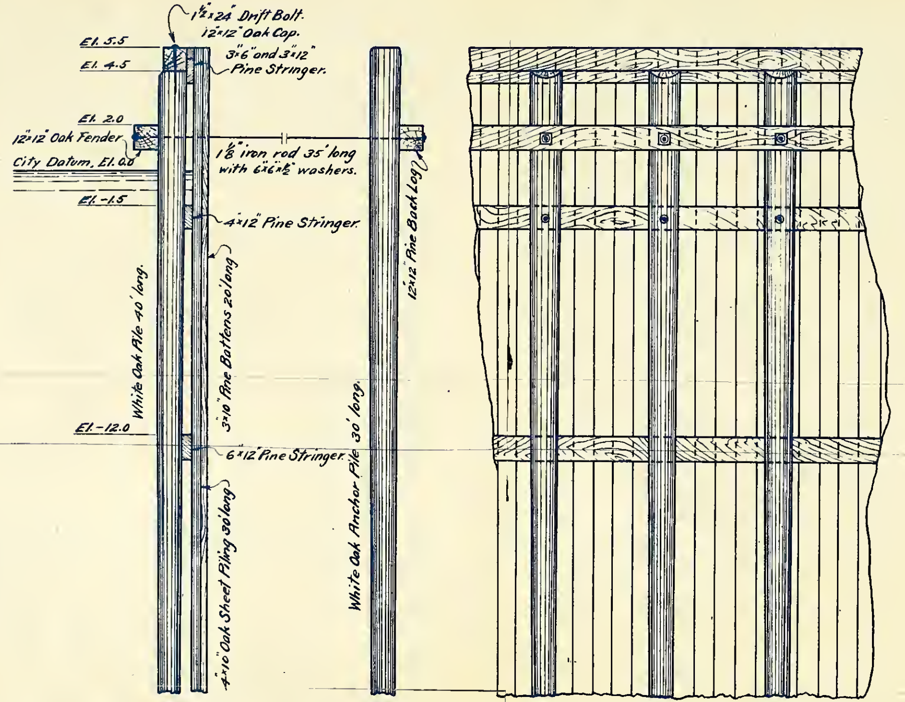
The largest area tributary to any pile in the piers is sixty square feet. At an assumed load of 350 pounds per square foot, this would make the maximum load to be carried by one pile 21,000 pounds. Since the safe value of a pile in a sound bearing surface of sand may be taken as 19 tons, the above figure is within the limits of safety.

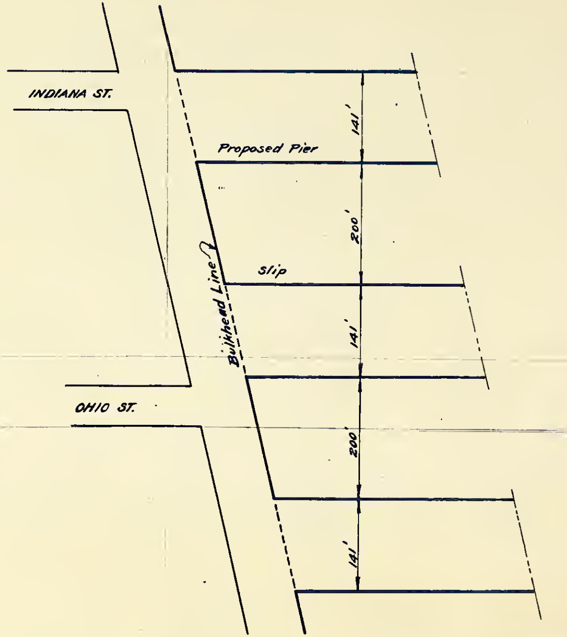
EXTRACT FROM
CITY DOCK SPECIFICATIONS

DOCK OR FRONT PILES

To be straight, sound, white oak piles, 40 feet long, tapering gradually from point to butt; not less than eight inches diameter inside the bark at small end and not exceeding 18 inches inside the bark at butt end. All bark shall be stripped from the parts of piles that will project above water line after driving.

The dock piles shall be driven, spaced, not exceeding 5 feet centre to centre, well aligned.





DESIGN and LOCATION
of
BULKHEAD

THESIS of T.J.FERRENZ.
May 1911.

ANCHOR PILES

To be 30 feet long and 18 inches in diameter at the butt. To be driven as shown on plans in a line parallel to the front row and not exceeding 8 feet centre to centre, and at a distance from the front row to allow anchor or tie rods 35 feet long to be used.

BACK LOGS

To be placed behind the anchor piles, with the top surfaces about 2 feet above — — — Chicago datum. The back logs shall be 10 X 12 inches, Norway pine, or 12 X 12 inch hemlock, laid against the anchor piles which shall be flatted at crossings to give better bearings.

The sticks shall be not less than 16 feet in length, each.

CAPS

The front or dock row of piles shall be sawed off in one horizontal plane and capped with one course of sound white oak, at least 12 X 12 inches, the stock in the caps to be not less than 22 feet in lenghh and joined together with splice joints machine bolted through the splices with two $14\frac{1}{2}$ X 1 inch machine bolts at each splice, driven in holes bored 1 – 16 in. less diameter than bolt. The caps shall be bolted to the heads of the piles by one headed drift bolt 24 inches long and $1\frac{1}{2}$ inches in diameter, at each pile head crossing. Nailed or spiked to the cap timber in rear and immediately above the upper stringer shall be placed a 3 X 6 in. white oak filler overlapping the splices in the cap, making the cap practically 12 X 15 in. white oak. There shall be four 10 X $\frac{3}{8}$ in. boat spikes, two on each side of splices in cap timber, driven through the filler and into the cap timber,and at intervals not exceeding 4 feet, and at each end of the filler planks there shall be driven two spikes.

STRINGERS OR TRIMMERS

To be three in number to support the dock sheeting. One stringer, 3 X 12 in. white oak, shall be placed just below the cap filler and spiked to the piles with two 10 in. steel wire nails or boat spikes at each pile and at each end of plank; one 4 X 12 in. pine shall be placed .33 feet below Chicago City Datum, and one 6 X 12 in. pine shall be placed 12 feet below Chicago City Datum as mud sill.

SHEET PILING

Each pile to consist of 4 X 12 in. white oak or Oregon Fir plank, 30 feet long, driven close behind the front row of piles. Said plank shall have bearing on the stringers and mud and be securely spiked through the cap filler to the 12 X 12 in. cap timber.

BATTENS

The joints or cracks between the sheet plank shall be carefully battened with 3 X 12 in.

pine batten, either white, Norway, or long leaf yellow pine, 20 feet long, properly nailed on.

Sheeting or batten cracked or split in driving shall not be accepted.

THE RODS

To be 35 feet in length, of wrought iron $1\frac{1}{4}$ in. diameter, placed not exceeding five feet apart, passing through each front pile through lower wale and through the back log. The rods shall pass through the front piles at about 1.5 above water level.

The rods shall have button heads not less than twice the diameter of the rods, and shall have their screw ends upset to $1\frac{5}{3}$ diameter and furnished with standard nuts.

Under both heads and nuts shall be placed wrought iron or steel washers 6 inches square and $\frac{1}{2}$" thick. Seats shall be properly placed to give firm bearing to the washers against piles and back log.

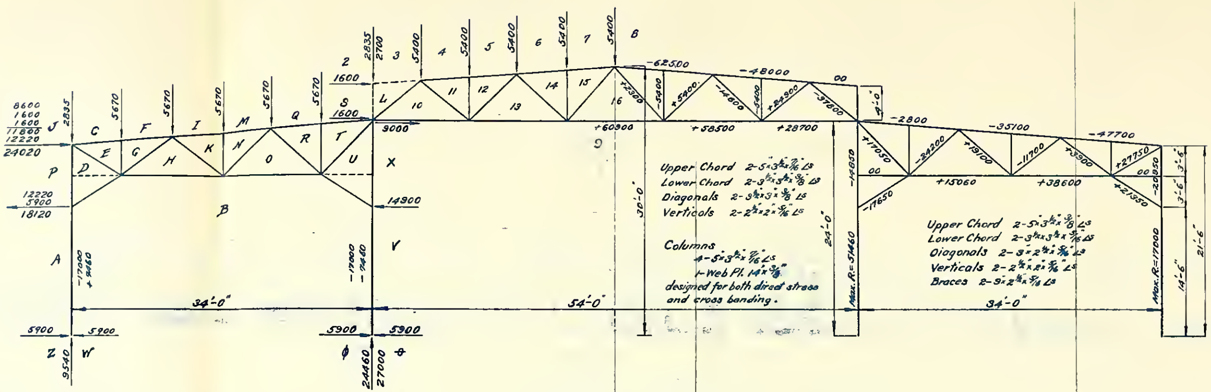
WALES

To be of white oak 12 X 12 in. and placed as shown in plan. They shall be made continuous by splice joints with the planes of splices vertical. The $\frac{3}{4}$ in. drift bolts, 12 inches long, shall be driven through each splice in the wale.

The wales shall be secured to the piles by rough pointed 1 $\frac{1}{4}$ in. drift bolts, 21 inches long, with swaged or enlarged heads driven in holes bored $\frac{1}{16}$" less in diameter than the bolts, one at each and every pile crossing.

SUPERSTRUCTURES

The design of the superstructures embodies in the main the principal features of the pier sheds recently constructed for the Boston Terminal of the Boston and Albany Railroad, and for the new San Francisco shipping piers. The framework of the sheds consists of transverse bents composed of four columns and a roof-truss spaced twenty feet on centers lengthwise of the pier to within twenty feet of the outer end which is open.



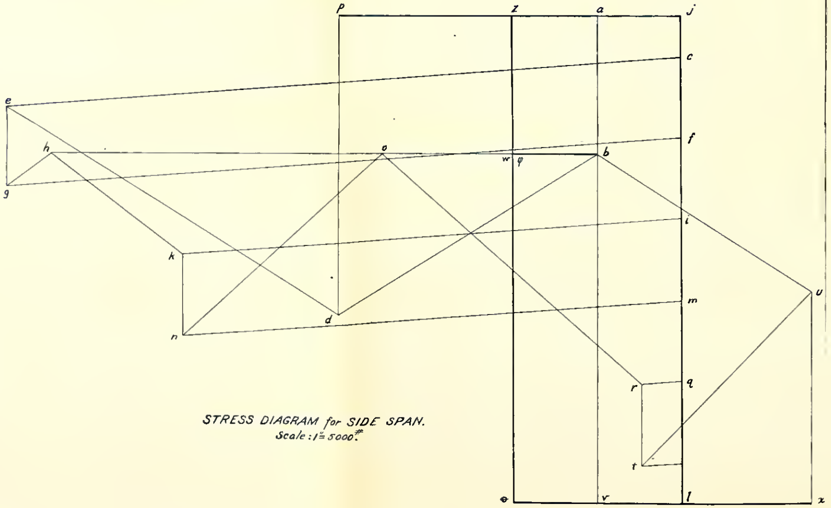
Upper Chord 2-5"×3½"×7/16" ∠s
Lower Chord 2-3½"×3½"×3/8" ∠s
Diagonals 2-3½"×3"×3/8" ∠s
Verticals 2-2½"×2"×5/16" ∠s

Columns
4-5"×3½"×7/16" ∠s
1-Web Pl. 14"×3/8"
designed for both direct stress and cross bending.

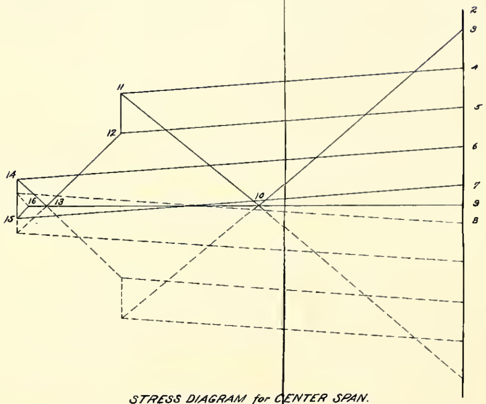
Upper Chord 2-5"×3½"×3/8" ∠s
Lower Chord 2-3½"×3½"×5/16" ∠s
Diagonals 2-3"×2½"×5/16" ∠s
Verticals 2-2½"×2"×5/16" ∠s
Braces 2-3"×2½"×5/16" ∠s

ELEVATION of PIER SHED.
Scale: ⅛"=1'.

End Reaction due to Vertical Loads = 17000#.
Overturning Moment = 11800×21.5 = 253700'#
Stress in Columns due to this M. = 253700/34 = 7460.#
Balancing Force at top of End Column = 5900×14.5/7 = 12220.#
Center Column = 5900×14.5/9.5 = 9000.#
Max. Bending Mom. in Column = 5900×14.5 = 85540.'#



STRESS DIAGRAM for SIDE SPAN.
Scale: 1"=5000.#



STRESS DIAGRAM for CENTER SPAN.
Scale: 1"=10000.

LOADS.
Total Roof Load - 50# per Hor. sq.ft.
Wind on Column - 40# per Vert. sq.ft.

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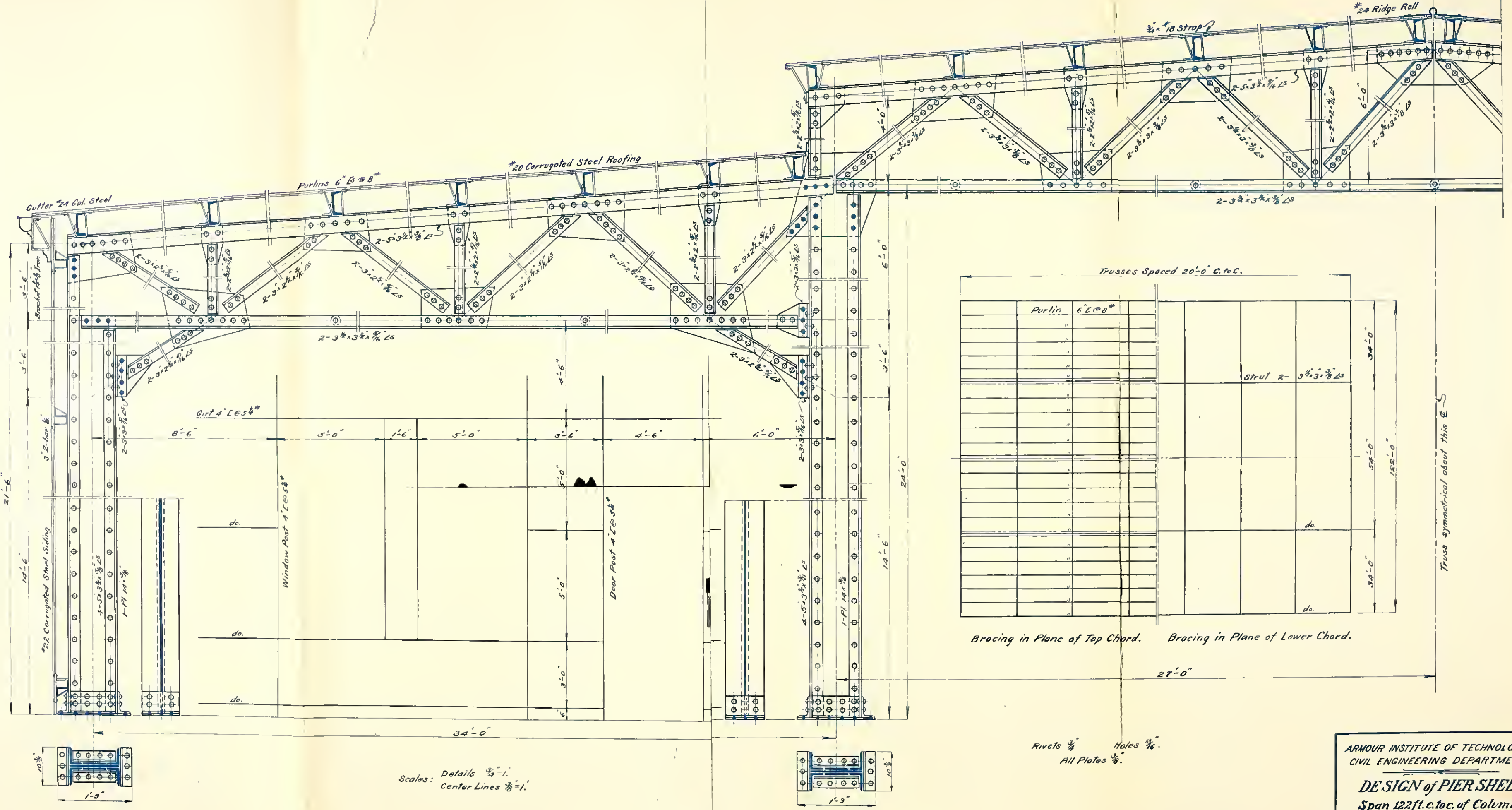
STRAIN SHEET for PIER SHED
Span 122 ft. c. to c. of Columns.
May 1911. Thesis of T.J. Ferrenz. Scales noted.

The roof truss is composed of three sections as shown on the accompanying print. The middle portion has a span of fifty-four feet with a rise of six feet at the center. The side portions, which are alike, are 34 ft. in span with a rise of 6 ft. where they are attached to the central portion. The clear head room at the center is twenty-four feet and at the sides 18 feet. The trusses are designed for a total vertical load of fifty pounds per square foot (including wind and snow). They are braced transversely to withstand a horizontal wind pressure at the side of the shed of forty pounds per vertical square foot.

The columns are composed of an I-Section built up of four angles and a plate. The chords, web members, and knee braces of the trusses are longitudinally braced at the upper extremities of the columns by struts composed of two angles. The roofing is no. 20 corrugated steel and is supported by 6" channel purlins.

All sides, except where windows and doors occur, are covered with no. 22 corrugated steel



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CIVIL ENGINEERING DEPARTMENT

DESIGN of PIER SHED
Span 122ft. c. to c. of Columns.
Thesis of
T.J. Ferrenz.
May 1911.
Scales noted

sheeting fastened to 3" "Z—Bars."

Partition walls are constructed of terra-cotta block filling in a channel and angle framework. Where these walls face waiting rooms and offices, they are finished with 2—coat plaster; elsewhere, they are covered by no. 22 galvanized sheet. Waiting rooms, offices, etc., have a ceiling of stamped sheet steel.

Large doors occupy nearly all the space between the wall' columns in the sides of the sheds. They are of the Kinnear rolling steel type and are arranged on two tracks. Ventilation is provided by pivoted windows in the sides of the center truss. These are operated by a system of gearing, in blocks 100 feet long, with fifteen windows to a block. Alternate panels of the building are lighted with central 11 X 18 feet flat sky—lights.

The equipment of the buildings includes steam—heating apparatus for offices and waiting rooms incandescent lamps for the offices and arc lights for the roarway and warerooms. Fire protection is afforded by a complete system of fire mains, hose,

nozzles, and automatic sprinklers so that any fire originating in the contents of the building may be immediately controlled.

COST DATA

On account of the absence of any undertaking with close similarity to the Chicago project, it is difficult to obtain an accurate estimate of the probable cost. A few examples will be cited, however. The timber pier, with steel sheds, recently constructed by the Boston and Albany Railroad at Boston is 240 feet wide and 781 feet long and cost complete $700,000 or about $4.00 per square foot. The principal quantities of materials used were 6,200 piles, 1,500,000 feet timber(board measure) 900,000 square feet plaster board, and 1900 tons structural steel.

According to data published by the Department of Docks and Ferries of New York City, the cost of timber piers there varies from $1.00 to $2.50 a square foot, depending upon the length

and number of piles used. An average pier with piles from 60 feet to 70 feet, in length, costs $1.20 complete, exclusive of super-structure. The pier sheds recently built in the Chelsea Improvement for trans-Atlantic steamships give the following data:

Pier No.	Size	Cost of Shed	Cost per square foot
54 & 56	104 X 825	$1,132,520	$6.60
57—8—9	129 X 825	$1,829,000	$5.73
60—1—2	129 X 825	$1,543,960	$4.84

Data on three new piers in the Baltimore Harbor is also available. Pier no. 1 is 551 feet in average length and 150 feet wide over all. It has a wooden pile substructure, with masonry side walls, earth fill, and paved surface. Pier no. 2 is 200 feet wide and 638 feet in average length, and Pier no. 3 is 200 feet wide and 772 feet in average length; both are substantially the same in construction, as Pier no. 1.

Their aggregate area is 362620 square feet.

The tatal cost was $550,000 or $1.52 a square foot. These piers were completed in April 1908 and are now partially occupied by six companies who pay an annual rental of $96,000.

Following is a list of the principal quantities involved in the construction of three pieces as designed for the Chicago Harbor:-

Dredging and casting over 245000
    cu. yards, at 20c ---------- -- $49,000

Piling, Material 21c per lin. ft.
    Driving 4c per lin. ft.
    Total 25c

18,108 piles, 50 ft.long at 25c, 226,350
9899 piles, 40 ft.long at 25c, 92,990
154 piles, 30 ft.long at 25c, 1,150
$ 320,490

Lumber,
    Yellow pine delivered—$30 per M. (board measure)
    White oak " $45 per M.
    Labor $20 per M.

Oak: Waling 101M. at $65 — — — $6,565

Yellow pine:

Ranger system	2074 M.
Sheet piling	3161 M.
Curbing	38 M.
Flooring	2091 M.
Transverse stringers	417 M.
Transverse bracing	482 M.
Longitudinal bracing	447 M.
Capping	1200 M.
Total — — —	9910 M.at $50

— — $495,500

$502,065

Struc118al steel:

118 trusses at 16676 pounds — — —	1967.4 tons
Longitudinals	37.3 tons
Purlins	245.4 tons
Girts	4.0 tons
Per pier	2254.1 tons
Three piers	6762.3

Cost of steel in place,4c per lb.

Total cost ----------- $540,984

To the foregoing items must be added 127440 sq. ft. of Shuman sectional bituminated pavement $3\frac{3}{4}$ inches thick, 431,880 sq. ft. of no. 20 corrugated steel roofing, 13,396 sq. ft. of no. 22 corrugated steel siding, 1268 sliding doors, 990 ventilator windows, and various other items of interior furnishing and equipments.

From the foregoing considerations it appears that the cost will average about $5.00 a square foot, making a total ,(for the three piers complete with superstructure) of --- $2,538,000.

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